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ABSTRACT

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THE PURPOSE OF ANALYTICAL MODELS FROM THE PERSPECTIVE OF A DATA PROVIDER

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Abstract

The purpose of analytical models is to reduce complex institutional management problems and situations to simpler proportions and compressed time frames so that human skills of decision makers can be brought to bear most effectively. Also, modeling cultivates the art of management by forcing explicit and analytical consideration of important internal institutional relations and alternative policies, as well as strengths and weaknesses of institutional data bases and management information systems. This paper discusses the application of analytical models to higher education management from the vantage point of the data provider. Topics include management interests acceptable to modeling, data base/computer perspective, the interface between the decision maker and analytical models, limitations of modeling, and the question--to model or not to model.

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The purpose of analytical models is to reduce complex institutional management problems and situations to simpler proportions and compressed time frames so that human skills of decision makers can be brought to bear most effectively. Also, modeling cultivates the art of management by forcing explicit and analytical consideration of important internal institutional relations and alternative policies, as well as strengths and weaknesses of institutional data bases and management information systems. Given traditional university administration by consensus among large numbers of competing, equal and vocal interests, the educative attributes of modeling are even more potent than in many business situations where management decisions are taken by relatively smaller numbers of people who are full-time managers. Further, modeling is one of the tools of the systems approach to university management. Since approaches are difficult to delimit, it seems best to describe and illustrate this approach and so assist the reader gain insight. In this context, the purpose of this paper is to discuss the application of analytical models to higher education management from the vantage point of a data provider.

The data provider has two primary perspectives of models. These are from the data base which supports the model (and other aspects of the management process) and from the interface between the model and the decision maker. The data provider sees the model as part of an integrated

university management information system. He is aware of the weakness of the data base and the limitations of the model and modeling. He assists in the formulation of the decision maker's questions and the presentation of the response such that the manager obtains the information he needs timely and in a form which permits him to use it. Thus, the data provider may not be one person or even one department. Often, offices of institutional research or analytical studies perform the role of a data provider.

Management Interests Susceptible to Modeling

In order to treat the demands on the data provider and thus illustrate his dual perspectives, it is helpful to review the kinds of problems to which modeling is applied. Most models, like the institutions they imitate, are student-enrolment driven. Historical and anticipated student flow patterns in institutions or even in the total postsecondary educational sector are important determinants in most institutional management and planning decisions. Thus, enrolment forecasting is one of the uses of models which must be supported by and in return support the data provider. Another is academic planning and curriculum design. Models can contribute to the planning process by showing the relations between institutional goals and objectives and resources required by academic and other programs designed to achieve them. Since many aspects of space and facilities are relatively easy to quantify and measure, these resources usually can be proportioned among the university or college programs to which they contribute. Also, models form a component of the information systems used for space and facilities planning, inventory and control. Academic and support staff requirements of an institution depend upon its academic plan

and the detailed determination of these resource needs is another application of modeling. Further, for financial planning and budgeting purposes, models are useful in translating resource requirements and revenue calculations into cost projections and budget allocations.

The ordinary use of analytical models is to simulate the institution under prescribed conditions and/or inputs of interest and to perceive certain consequences, usually resource requirements. The first extension of this mode is to answer "what-if" questions. The usual what-if merely changes the operating point of the model with respect to some parameter(s) of interest or varies inputs. What-if questions are asked because someone has a hunch that the proposed operating point is "better" in some sense or because there is an interest in determining the sensitivity of some output to a prescribed change in the input. Thus, the purpose of the what-if question is to ascertain information helpful in optimizing the enterprise against some criterion. This use of models raises the point--why not use an optimum seeking model which answers the what-ought-to-be question? Unfortunately, few existing models have an optimizing capability.[1] This limitation in the state of the art of institutional simulation is one reason why the interface perspective of the data provider, to which we will return later, is important.

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[1]A concise review of the literature of the application of mathematical programming models to institutional management problems is given in: James F. McNamara, "Mathematical Programming Applications in Educational Planning," Socio-Economic Planning Sciences, Vol. 7 (1973), pp. 19-35. Most applications of optimization techniques have been directed to the solution of problems at levels below the institutional level, that is, at the department level or have been concerned with optimum use or deployment or specific institutional resources such as space.

Data Base/Computer Perspective

A model which simulates several processes requires information from an integrated data base. This implies that information typically collected for specific purposes in an institutional operating department must be meaningful when it is used with information from other sources. For example, information from the student file, academic personnel file and the institutional timetable must be comparable for analytical purposes. Thus, the method of data collection, data element definitions, date of record, systems maintenance procedures, procedures for access to files for both reading and writing, must be appropriately coordinated so that information fed into the model is unambiguous, is generated by compatible systems, and meets the model's specifications for input data and parameter values. Thus, the model's need to be supported by an integrated data base (or integratable data) may lead to additional costs, changes in procedures, and perhaps even organizational and personnel changes in the institution which may not be required if a model is not used. These costs and changes may be difficult to justify in an institution which is functioning adequately without manifest weakness in the information required by the operating departments and others in the performance of their duties. These costs must be weighed against the benefits of the availability of data from all sources being useable and understandable to more people for more applications--especially institution-wide management and planning applications.

The demands on the institutional data base if the model is to simulate the institution under many different circumstances or if the model is interactive need not be generically different, although they may differ in

degree, than when the model is used for one-shot runs. However, if the model is on line, such that the institution's current operational data base must be instantaneously and automatically accessible so that there is no opportunity to manipulate or adjust the data, then the demands on the data base and its supporting systems are an order of magnitude more difficult and costly to meet.

If the model is used as a simulator to compare the influences of a large number of changes in institutional operating points or inputs, then many iterations or runs of the model are required. Suppose, for example, that one run of the model costs $300 in computer time. It is apparent that use of the total model to cut and try a large number of alternatives with a view to finding an optimum may be a use of the model which is prohibitively expensive. The use of models to seek local or even global optima is one which should be given more attention by model builders, users and data providers. Among the most important advances which must precede widespread use of practical optimizing models include a clearer understanding and more precise definition of educational production functions which relate to suitable outputs or proxies within the institution. However, from the data provider's point of view, there may be, even given today's technology, better trade-offs possible with respect to model size and comprehension, data base requirements, hardware requirements and the range of optimizing problems to which models might be applied.

The point of view of analytical models as component devices in the total management process of the institution helps illustrate the data provider's perspective. Considering the model as a facet of an integrated university management information system shows model dependency on other

parts of the information system and emphasizes the areas of its impact.

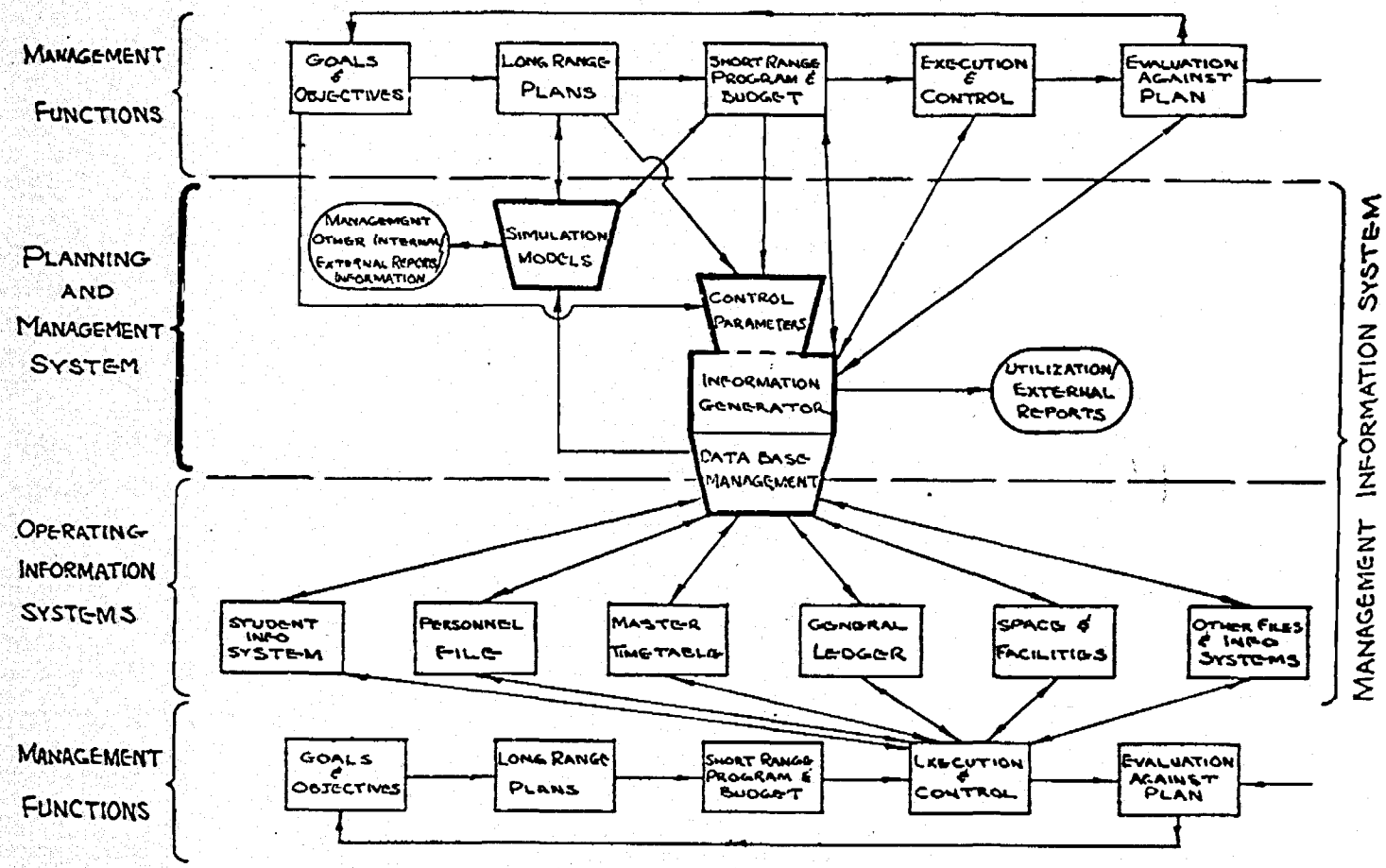
Recognizing the dangers of using a simple diagram (model!) to illustrate a complex multidimensional set of relations, Figure 1 shows some of the relationships of the model relevant to this discussion. The figure indicates that the principal data input of the model is from the data bases maintained by the operating departments and orchestrated by a data base management system. Further, it implies aspects of the relationship between the problems/costs of data base generation, maintenance and control and the benefits of modeling.

The figure also helps isolate three main classifications of university information systems. These classifications are not mutually exclusive nor even rigidly defined but they help illustrate the place of analytical models in the information system structure without depending too heavily on the somewhat obfuscating technical jargon of systems specialists. In the diagram, operating information systems refer to that set of methods, procedures, definitions and systems for the preparation and integration of data to satisfy the institution's needs for operating information. This includes the working documents required in the routine function of the institution such as budget statements, payrolls, course statistics, student statistics, class lists, grade reports, inventories and timetables.

Management information system (MIS) is a general term which usually refers to that set of methods, procedures, definitions, standards and systems for the preparation and integration of data to satisfy the institution's needs for management control and utilization information. Normally, this includes, for example, reports of program costs, instructional loads and space use. However, with the addition of the model the notion of MIS

Figure 1

DATA PROVIDER PERSPECTIVE OF INSTITUTIONAL SYSTEM INTERRELATIONSHIPS IN HIGHER EDUCATION



is extended to include what might be called a planning ard management system (PMS). A PMS includes that set of policies, standards, procedures, reports and systems associated with all aspects of institutional planning, including the relationship between institutional goals, programs and resources. The model may also be used to generate utilization reports such as historical or actual data on program costs, space utilization and faculty and student loads. But these can just as well be produced from the data base by an information generator following certain algorithms. The analytical model goes beyond the algorithm by permitting simulation of the institution under differing or alternative circumstances and with the view of providing planning information.

The management functions are depicted in the figure in order to contrast the relationships of the operating information system and the planning and management system to these functions. The operating information system relates primarily to the departmental administrative functions of execution and control. The relationship of the PMS to the management functions is characterized by a more complicated dependency and interaction which involves all the management functions.

Interface Perspectives

The interface perspective arises because of the mismatch between the busy executive and analytical models provided by the present state of the art. Current man-machine problems are such that the executive would not find the model input-output devices man-oriented, the range of problems the model can handle directly are limited, and he would be further hindered because present models are not highly adaptive. The absence of these characteristics and the fact that most managers do not have the time to

formulate their questions analytically mean that the data provider must serve as the interface between the executive and the model.

The data provider helps the executive formulate his problem. The problem must be the executive's; it has to be within the limitations of the model and the ancillary support ability of the data provider. Thus, the data provider and the model are "seen" by the executive as a "black box." When the solution is generated, it needs to be translated for the executive. Sometimes the output directly from the computer is formatted so that it is as required by the executive. Often, the output from the model run is merely data which must be integrated manually with other information, structured and ordered such that it is in a form (even a medium) which makes it understandable and useable by the executive.

Another aspect of the interface perspective of the data provider is toward the model. The executive's problem must be translated so that it can be inputted to the model. There are the technical details of making the problem machine-readable. These are important and there may be costs associated with them. However, the more important and prior issue is the formulation of the decision maker's query into the problem-solving framework of the model.

Man does not live by data alone, but needs collateral intelligence to interpret data and give them context. Thus, the data provider must understand the full ramifications of the executive's question and be able to relate to these in terms of the limitations of analytical modeling and the assumptions inherent in the given model design. Further, the data provider must make the consequences of these limitations known so that they can be taken into account by the executive as he makes his decision on the basis of the data provided.

Limitations

The output of the educational enterprise is difficult to conceptualize and is nonmeasurable. What we call outputs and inputs are usually only proxy variables for the real thing. Also, many important parameters such as average section size, course level, instruction type, are used in ways which attribute to them pedagogical characteristics which they may have but have never been measured. Thus, to avoid the insinuation that an analytical model quantifies a process which is essentially not quantifiable, it is necessary to observe that it is an oversimplification to say that an analytical model is an analog of an institution. It is more nearly an analytical simulation of a conceptual model of an institution. The model then embodies two sets of limitations: those associated with the builder's conceptualization of the educational processes within the institution, and those associated with the translation of the conceptual model into a computer simulation. Nevertheless, these limitations need not invalidate use of models in institutional management, but the limitations must never be lost sight of and the model output must not be granted status or meaning beyond the limitations of the model in the context of each application.

Notes for Rumination of Modeling from the Data Provider's Perspective

Should analytical models be used at my institution in the management process? The following considerations reflect the data provider's perspective on the question, to model or not to model.

1) Does the institution have an analytical support staff which could perform the role of data provider? Such a staff is needed to

implement, use, maintain and evolve the model whether it is built, borrowed or bought. In this regard it is worth noting that given the state of the art of modeling and general institutional experience with analytical models, immediate benefits from the initial experience with models will be the knowledge that those involved will gain about their own institution. Experimentation with an institutional simulation model is a structured method for instruction of support analysts and others in the value and use of analytical management tools and for the maturation and integration of data bases.

2) Are the data bases and associated information systems capable of supporting a model which will provide management information beyond that which is available within the institution now?

3) Is the cost of improving the data base included in cost estimates of model implementation? If the model program classification structure and data element definitions do not match the university structure or administrative practice, what are the "costs"?

4) Is the cost of maintaining the data base included in cost estimates of using the model?

5) Can the cost of improving and maintaining the data base be charged to other benefits which accrue beyond model use? In this regard, costs and benefits may be subtle. For example, improved data base may promote more efficient practices in operating departments while, on the other hand, attempts to improve data base may be seen as a threat by some departments and thus reduce overall efficiency by producing friction between individuals and departments.

6) What resistance by what sectors of the institution will be manifested by the introduction of an analytical model and associated data base

and information systems improvements? Passive indifference, especially on the part of key senior people, can be at least as counterproductive as overt reasoned opposition. Also, it must be remembered that everyone is for "progress." Thus, verbal approval and encouragement are no substitute for clearly established priorities backed up by specific budget allocations for the introduction of modeling.

7) There are a number of trade-offs: models for long-range planning generally make fewer demands on the data base than those used for short-range purposes; the greater the disaggregation of model capabilities, the more expensive the data base; on-line models imply competent data base management systems and integrated university management information systems. Other trade-offs such as accuracy, flexibility, upkeep, design problems, costs and convenience can be summarized as follows: the model must be simple enough to be understood and manipulated by users, representative enough to cover a significant range of applications, yet complex enough to precisely enough mirror the institution.

8) Modeling is useful in isolating some of the technical problems of generating normative and comparable interinstitutional data.

9) The effort to develop an integrated data base for the model may pay off by providing an effective and flexible way of generating many ad hoc and routine reports required by university management as well as by external agencies.

10) The application of models or other mathematical techniques to management problems at the departmental level may be at least as productive as attempting implementation of large general institutional models. Also, the analytical approach to departmental or specific institutional problems

such as space planning, scheduling or the deployment of faculty members may be more expeditiously handled if a concerted effort is made on them outside of the work associated with an institutional model.

11) Is the use of analytical methods compatible with the management style of the institution? Does the management information generated have application to problems of sufficient significance such that the associated costs are justified? The determination of whether modeling will be a useful tool presupposes considerable familiarity and understanding of the institutional management style.